

The invention claimed is:

1 1. A method of encoding information symbols for multiple antennae transmission
2 comprising the steps of:
3 generating a code matrix B_0 ;
4 generating a transformation matrix L where; and
5 combining the code matrix B_0 with the transformation matrix L to obtain a result B for
6 controlling the amount of beamforming relative to the amount of orthogonal coding in signals
7 transmitted from the multiple antennae.

1 2. The method of claim 1 wherein the transformation matrix L is a matrix such that,
2 when the conjugate transpose of L is multiplied by L generates a desired correlation matrix Φ .

1 3. The method of claim 2 wherein the code matrix B_0 is orthogonal.

1 4. A method of encoding information symbols for multiple antennae transmission
2 comprising the steps of:
3 generating a code matrix B_0 ;
4 generating a transformation matrix L where L satisfies the relationship
5 where $\Phi = L^H L$ is a desired correlation matrix Φ ; and
6 combining the code matrix B_0 with the transformation matrix L to obtain a result B for
7 controlling the amount of beamforming relative to the amount of orthogonal coding in signals
8 transmitted from the multiple antennae.

1 5. The method of claim 4 wherein the desired correlation matrix is comprised of at least
2 one correlation parameter λ .

1 6. The method of claim 5 wherein the transformation matrix L is the matrix square root
2 of the desired correlation matrix Φ .

1 7. The method of claim 4 wherein blocks of symbols of a serial data stream of user data
2 are encoded with an orthogonal code to form code matrix B_0 .

1 8. A method of generation signals for transmitting from at least two antennae of a
2 wireless communications system comprising the steps of:
3 feeding a stream of incoming information symbols to an encoder;
4 feeding a signal representative of a beamforming weight parameter to the encoder to
5 modify the stream of information symbols;
6 feeding a code correlation parameter (λ) to the encoder to control the proportion of
7 orthogonal coding relative to beamforming of the stream of information symbols that are to be
8 transmitted; and
9 feeding the stream of information symbols modified by the code correlation parameter to
10 at least two antennae for transmission.

1 9. The method of claim 8 wherein the code correlation parameter determines the
2 correlation of the encoded signals to the different antennae.

1 10. The method of claim 9 wherein the signal representative of the beamforming weight
2 parameter represents a complex number having a magnitude and a phase.

1 11. The method of claim 9 wherein the signal representative of the beamforming weight
2 parameter is of a real number of the phase of the beamforming weight parameter.

1 12. The method of claim 11 wherein the code correlation parameter is of a real number
2 can vary between a first value and a second value.

1 13. The method of claim 12 wherein one of the values represents orthogonal coding
2 with no beamforming and the other value represents beamforming with no orthogonal coding, and
3 intermediate values represent a combination of orthogonal coding and beamforming.

1 14. The method of claim 9 wherein, in a duplex communication system having a forward
2 and reverse link, the code correlation parameter is determined from signals received on the
3 reverse link.

1 15. The method of claim 14 further comprising the step of determining a channel
2 correlation coefficient (ρ) from the signals received on the reverse link.

1 16. The method of claim 15 wherein the channel correlation coefficient (ρ) is a complex
2 number from which the magnitude component and not the phase component is used to determine
3 the code correlation parameter λ .

1 17. The method of claim 14 wherein the channel correlation coefficient is an estimate of
2 auto-correlation coefficient of channel gain from an antenna for a fixed time delay.

1 18. The method of claim 17 wherein the delay is determined by the difference between
2 the time at which feedback information is transmitted on the reverse link to the time at which the
3 beamforming weight parameter computed using that information is applied by the forward link
4 transmitter.

1 19. The method of claim 18 wherein the delay is equal to the time difference multiplied
2 by the ratio of carrier frequencies on the reverse and forward links.

1 20. The method of claim 8 wherein the symbol signal transmitted by each antenna at
2 each symbol time is the sum of one or more signals, each of which is proportional to the product
3 of one of the incoming symbols and their complex conjugates and their negations and their
4 negations of their complex conjugates, with a number that is determined by lambda.

1 21. A method of forming a signal comprising the steps of:
2 obtaining at least two component signals;
3 multiplying a first component signal by a first complex number to obtain a first signal;
4 multiplying a second component signal by a second complex number to obtain a second
5 signal;
6 wherein the phases of the first and second complex numbers are unequal; and
7 subtracting the second signal from the first signal to obtain a first composite signal for
8 transmission by a first antenna element during a first transmit period.

1 22. A method of forming signals for transmission from an antenna element during two
2 transmit periods comprising the steps of:
3 obtaining at least two component signals for each transmit period;
4 multiplying a first component signal by a first complex number to obtain a first signal;

5 multiplying a second component signal by a second complex number to obtain a second
6 signal;
7 wherein the phases of the first and second complex numbers are unequal;
8 subtracting the second signal from the first signal to obtain a first composite signal for
9 transmission by the first antenna element during a first transmit period;
10 multiplying a third component signal by a second complex number to obtain a third
11 signal;
12 multiplying a fourth component signal by a first complex number to obtain a fourth
13 signal; and
14 adding the third signal to the fourth signal to obtain a second composite signal for
15 transmission by the antenna element during a second transmit period.

1 23. A method of forming signals for transmission from two antenna elements during two
2 transmit periods comprising the steps of:
3 obtaining at least two component signals for each antenna for each time interval;
4 multiplying a first component signal by a first complex number to obtain a first signal;
5 multiplying a second component signal by a second complex number to obtain a second
6 signal;
7 wherein the phases of the first and second complex numbers are unequal;
8 subtracting the second signal from the first signal to obtain a first composite signal for
9 transmission by a first antenna element during a first transmit period;
10 multiplying a third component signal by a second complex number to obtain a third
11 signal;
12 multiplying a fourth component signal by the first complex number to obtain a fourth
13 signal;
14 adding the third signal to the fourth signal to obtain a second composite signal for
15 transmission by the first antenna element during a second transmit period;
16 multiplying the first component signal by a third complex number to obtain a fifth signal;
17 multiplying the second component signal by a fourth complex number to obtain a fourth
18 signal;
19 wherein the phases of the third and fourth complex numbers are unequal;
20 adding the third signal to the fourth signal to obtain a third composite signal for
21 transmission by the second antenna element during the first transmit period;

22 multiplying the third component signal by the fourth complex number to obtain a fifth
23 signal;

24 multiplying the fourth component signal by the their complex numbers to obtain a sixth
25 signal;

26 wherein the fifth and sixth complex numbers are unequal; and

27 subtracting the fifth signal from the sixth signal to obtain a fourth composite signal for
28 transmission by the second antenna element during the second transmit period.

1 24. The method of claim 23 wherein the component signals are determined by at least
2 one incoming information symbol and at least one of the component signals is related to a code
3 correlation parameter.

1 25. The method of claim 24 wherein each component signal is related to at least one of
2 two information symbols, or their negations, or their complex conjugates or the negations of their
3 complex conjugates.

1 26. A method of forming a signal comprising the steps of:
2 obtaining at least two component signals;
3 applying a first phase to a first component signal to obtain a first signal;
4 applying a second phase to a second component signal to obtain a second signal;
5 wherein the first and second phases are unequal; and
6 combining the second signal and the first signal to obtain a first composite signal for
7 transmission by a first antenna element during a first transmit period.

1 27. A method of forming signals for transmission from an antenna element during two
2 transmit periods comprising the steps of:
3 obtaining at least two component signals for each transmit period;
4 applying a first phase to a first component signal to obtain a first signal;
5 applying a second phase to a second component signal to obtain a second signal;
6 wherein the first and second phases are unequal;
7 combining the second signal and the first signal to obtain a first composite signal for
8 transmission by the first antenna element during a first transmit period;
9 applying a second phase to a third component signal to obtain a third signal;
10 applying a first phase to a fourth component signal to obtain a fourth signal; and

11 combining the third signal and the fourth signal to obtain a second composite signal for
12 transmission by the antenna element during a second transmit period.

1 28. A method of forming signals for transmission from two antenna elements during two
2 time intervals comprising the steps of:

3 obtaining at least two component signals for each antenna for each time interval;

4 applying a first phase to a first component signal to obtain a first signal;

5 applying a second phase to a second component signal to obtain a second signal;

6 wherein the first and second phases are unequal;

7 combining the second signal and the first signal to obtain a first composite signal for
8 transmission by a first antenna element during a first time interval;

9 applying the second phase to a third component signal to obtain a third signal;

10 applying the first phase to a fourth component signal to obtain a fourth signal;

11 combining the third signal and the fourth signal to obtain a second composite signal for
12 transmission by the first antenna element during a second time interval;

13 applying a third phase to the first component signal to obtain a fifth signal;

14 applying a fourth phase to the second component signal to obtain a fourth signal;

15 wherein third and fourth phases are unequal;

16 combining the third and fourth signals to obtain a third composite signal for transmission
17 by the second antenna element during the first transmit period;

18 applying the fourth phase to the third component signal to obtain a fifth signal;

19 applying the third phase to the fourth component signal to obtain a sixth signal; and

20 combining the fifth signal and the sixth signal to obtain a fourth composite signal for
21 transmission by the second antenna element during the second time interval.